

ATLAS Experiment Capabilities and Status

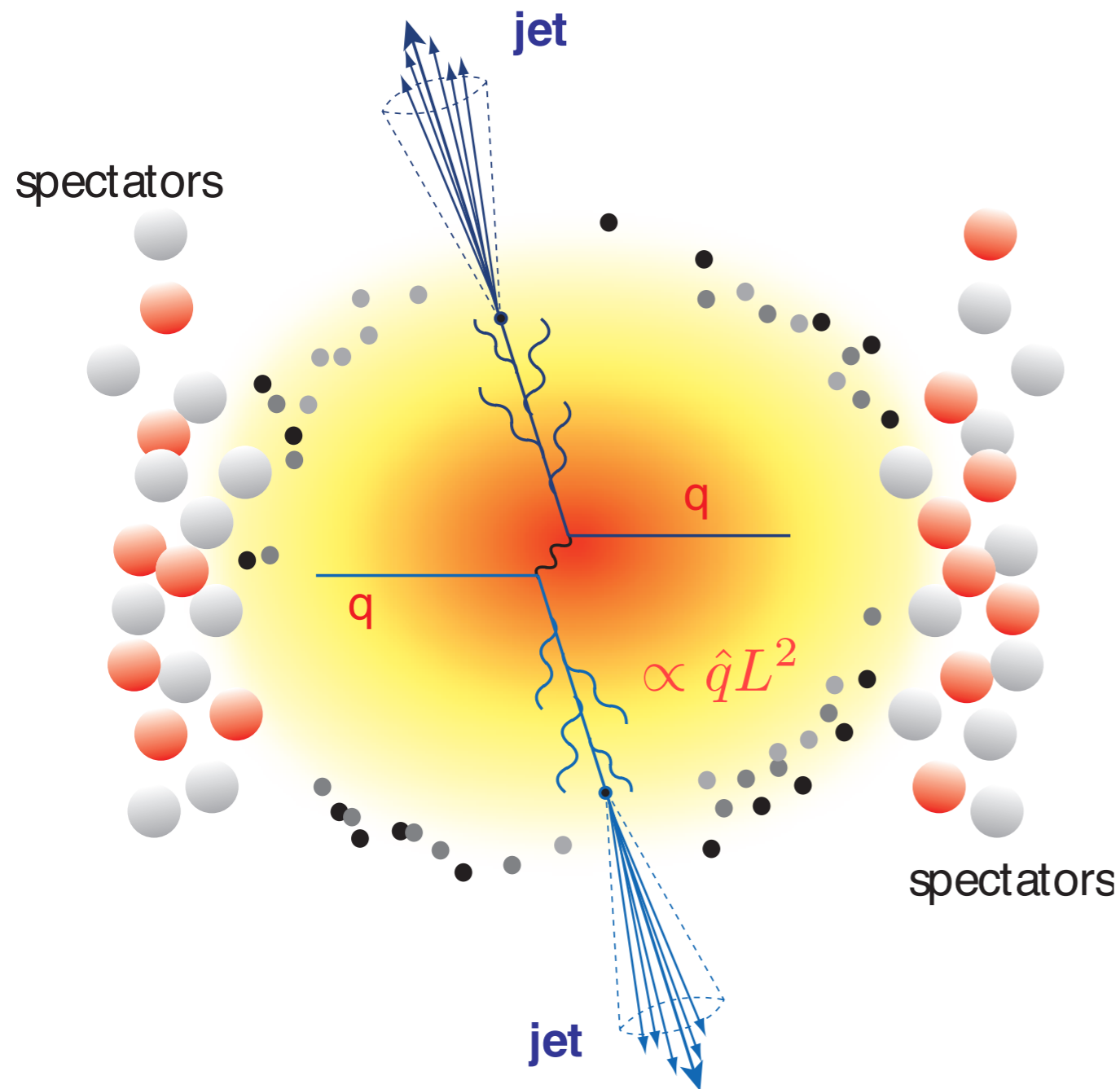
Helio Takai

Brookhaven National Laboratory

(for the ATLAS collaboration)



Physics Case was already made!



LHC heavy ion collisions are expected to produce a hotter, denser and longer lived QGP.

The increase in hard process cross section make them a good tool to explore the hot QCD matter.

The energy loss of hard scattered partons provides a direct probe of color charge density of medium.

Upsilon states and J/ψ can serve as thermometers of the hot QCD matter.

“Quenching” = induced gluon radiation



Yes, ATLAS!!

ATLAS has a hermetic and highly segmented calorimeter both longitudinally (*in* **R**) and transversely (*in* **η** and **Φ**).

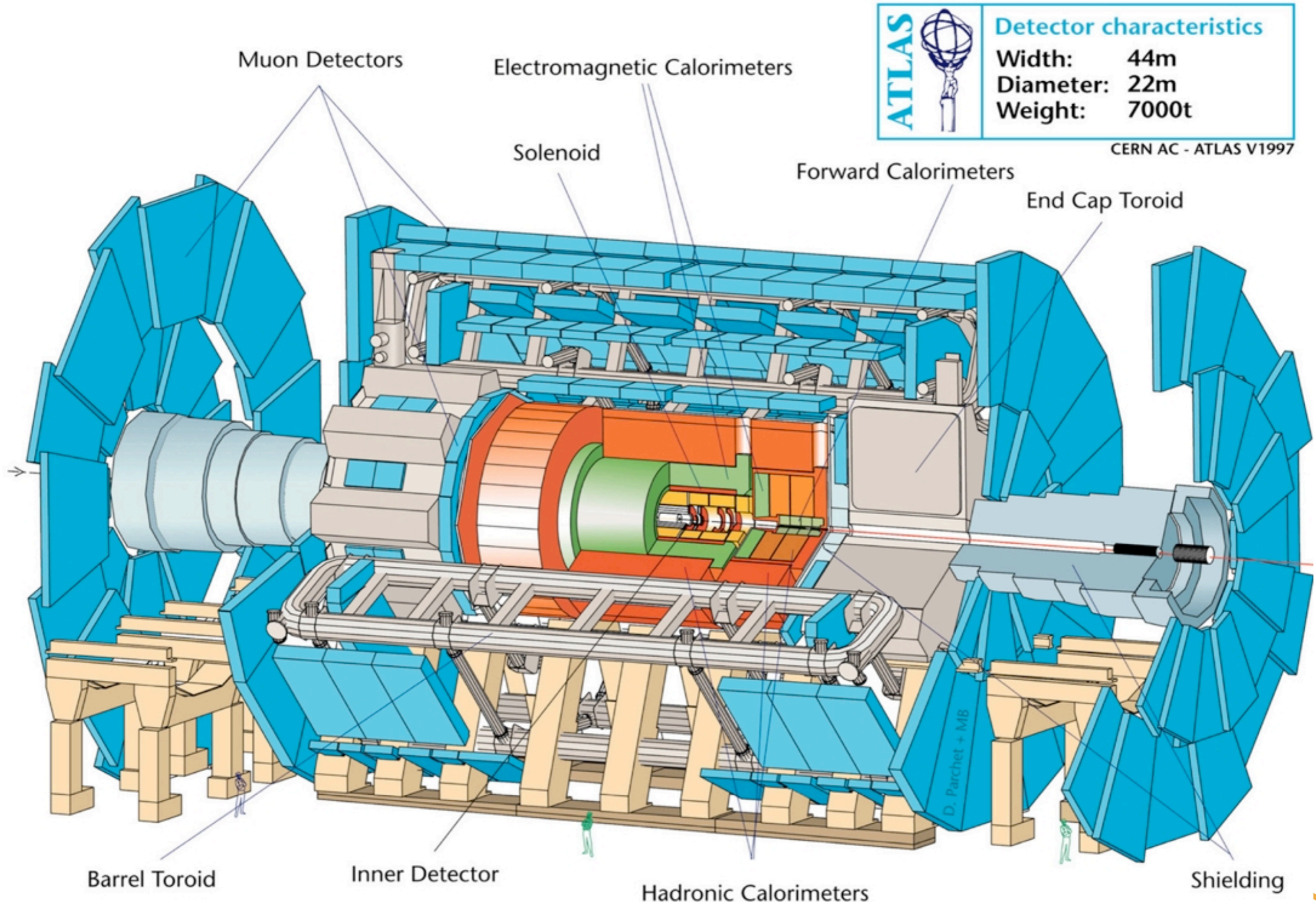
ATLAS has tracking that operates in the heavy ion environment.

ATLAS can study jets at moderate p_T where quenching is still strong and at very high p_T where quenching is expected to disappear.

Strong Interaction with the **ATLAS** QCD group!

... closer to the Cafeteria and T-shirts by Alan Alda!



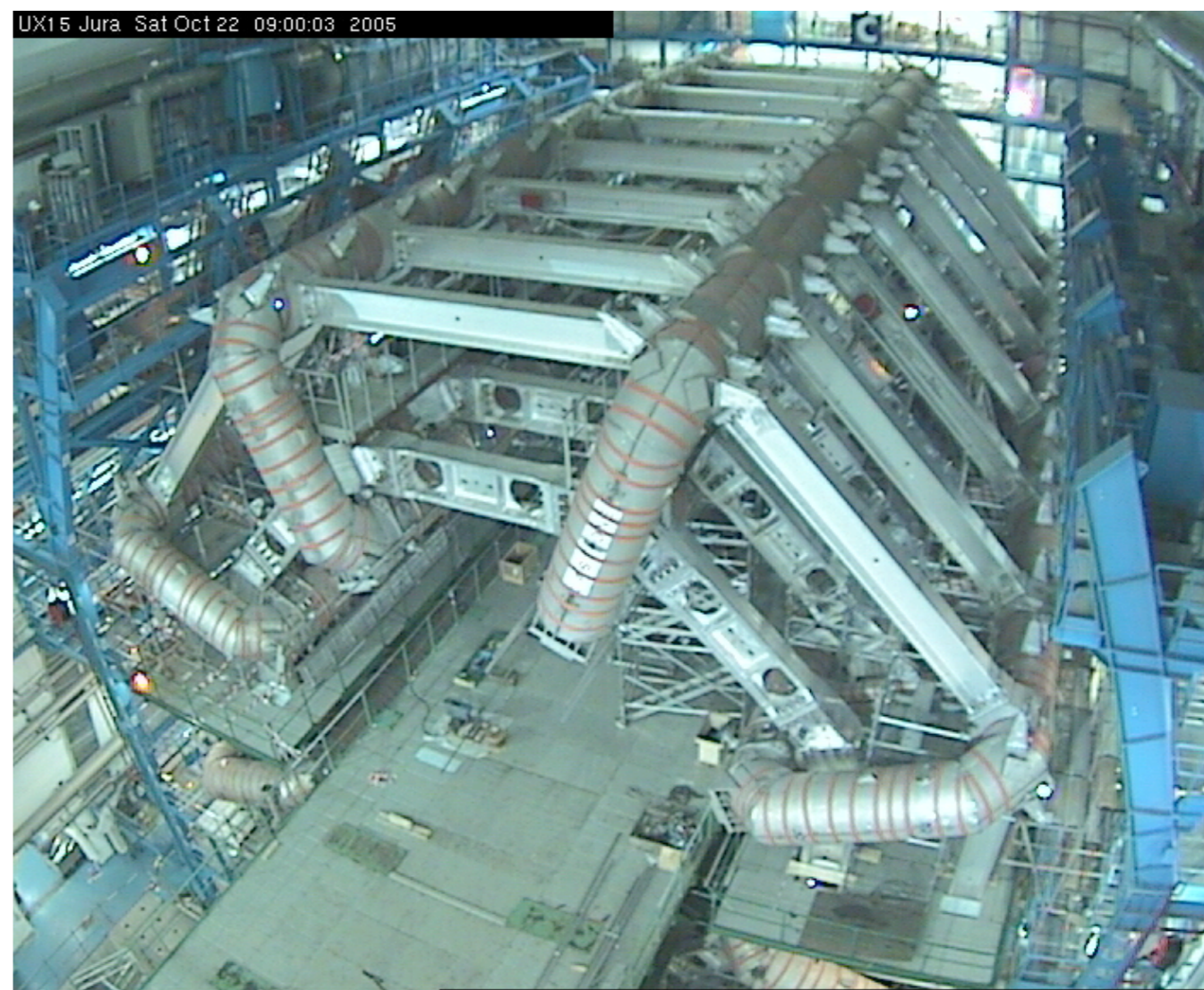


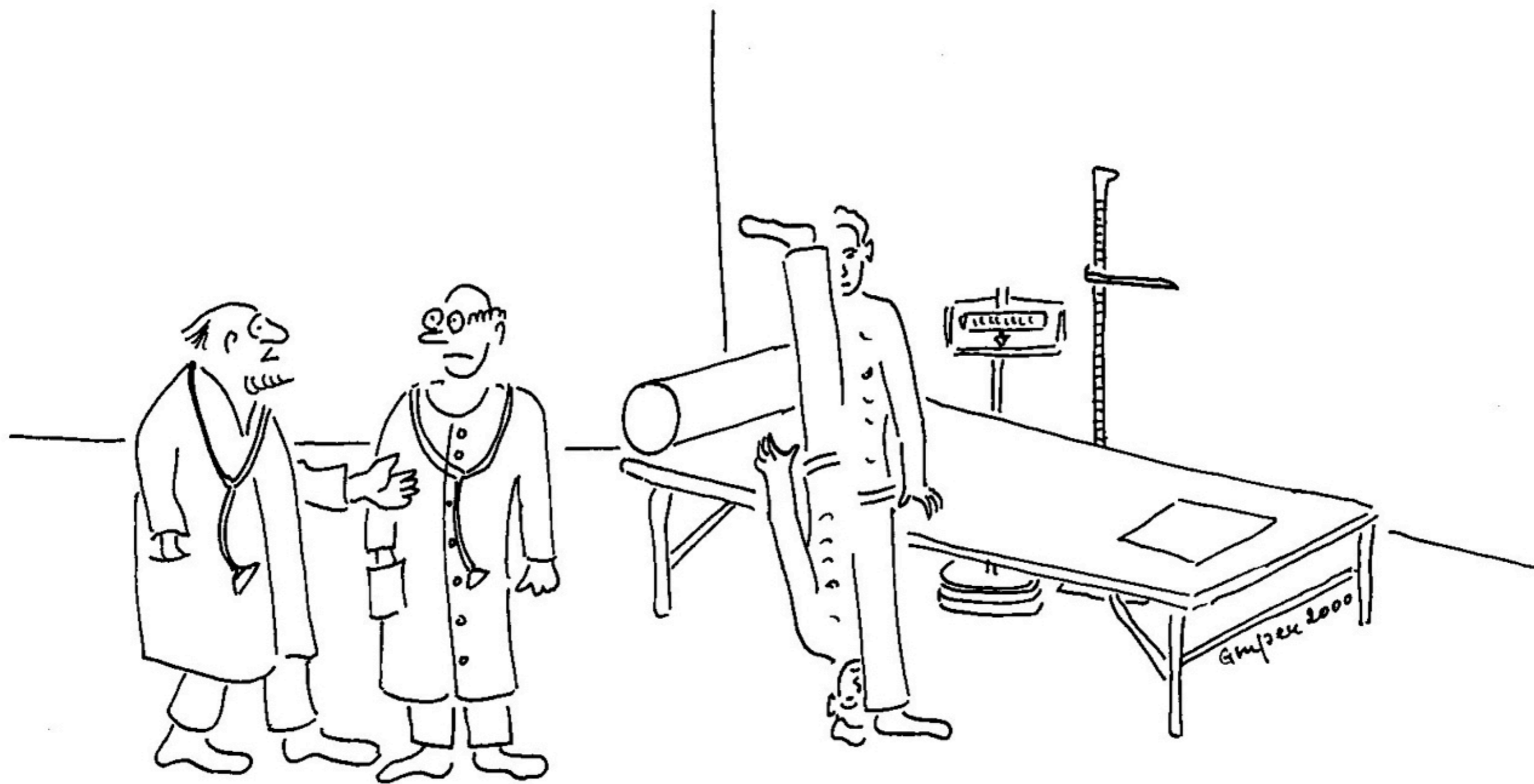
1900 physicists, 154 institutions, 35 countries
Designed for high p_T physics in pp collisions

PANIC 2005, Heavy Ions at LHC, October 23, 2005.



ATLAS Saturday

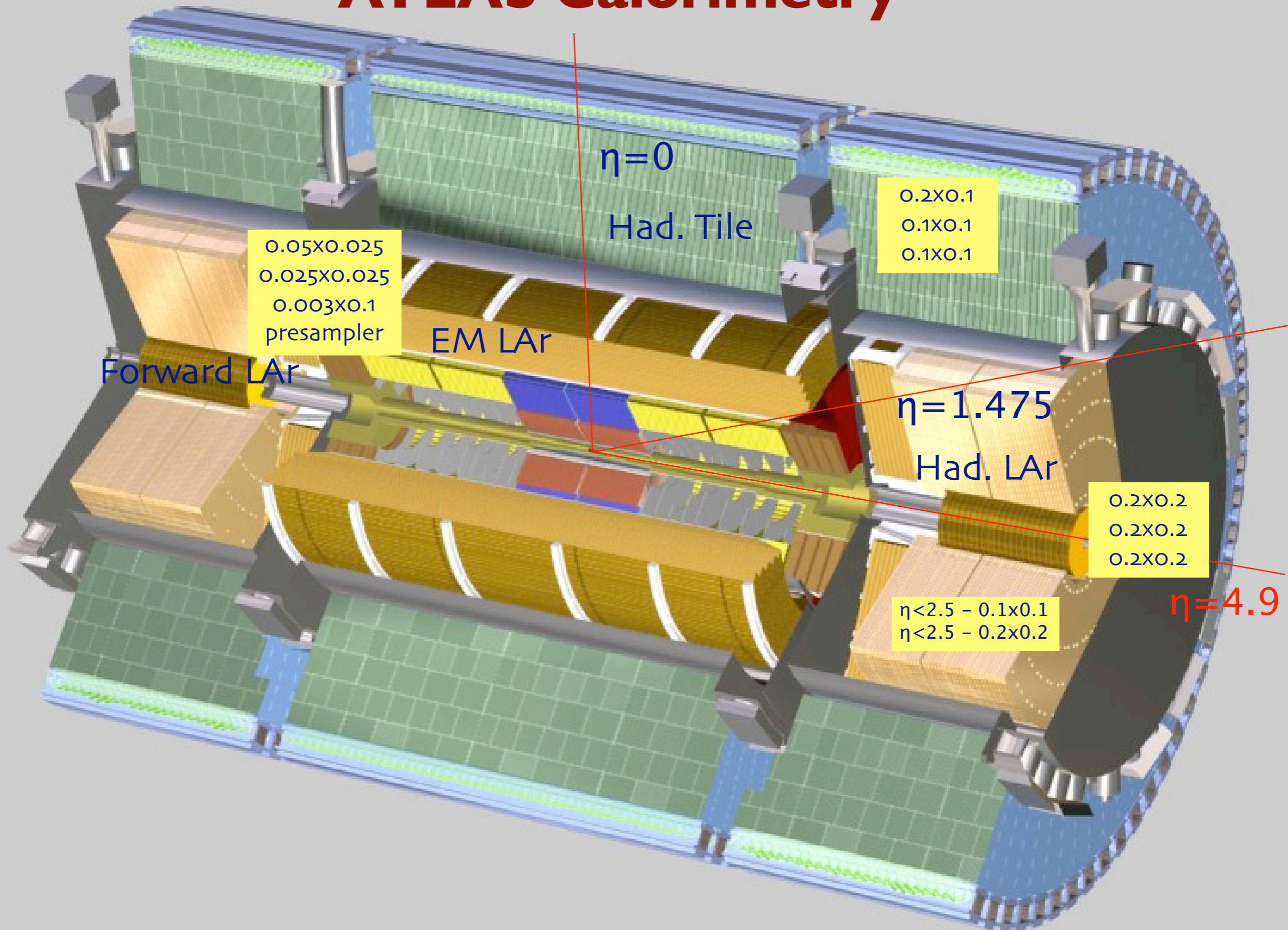




“A severe case of symmetry breaking!”



ATLAS Calorimetry



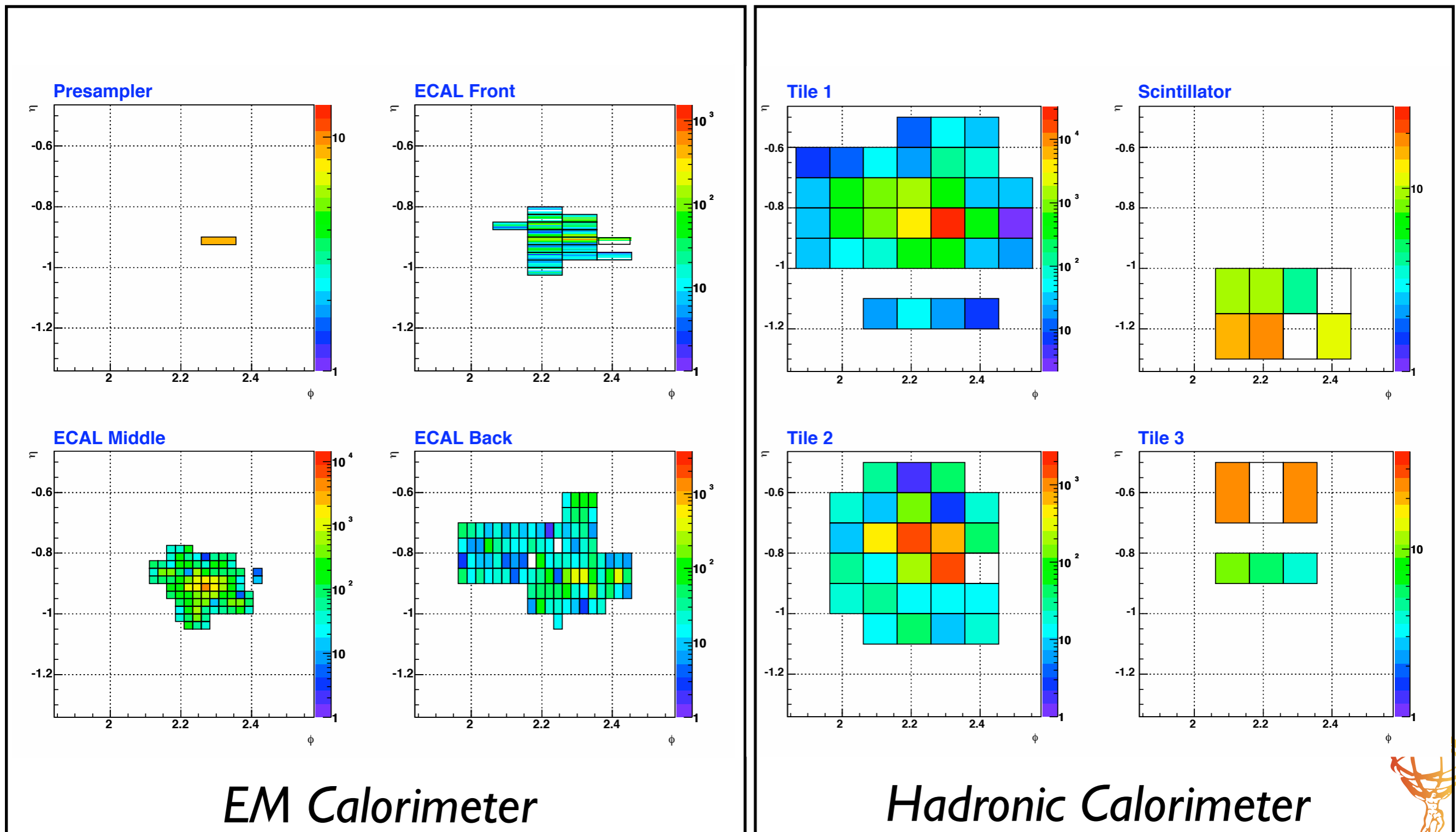
Contains 60% of soft background energy!

Jets in 3D!

(and in color)

$E_T = 100$ GeV (jet only)

$\Delta\eta \times \Delta\phi = 0.8 \times 0.8$



The Physics Program

“Jet physics”, Quarkonia and Minimum Bias

Global variables, Flow, multiplicity, $dN/d\eta$, $dE_T/d\eta$

Inclusive jet cross section ($E_T > 40$ GeV)

Multi jet events (e.g. three jet events)

Heavy quarks - b-jets

“Calibrated” jets - $\gamma+j$, Z^0+j , γ^+j and others*

Measurement of jet fragmentation properties

“Energy Loss” vs reaction plane

Quarkonia - Υ and J/ψ

proton-nucleus collisions

ultra-peripheral collisions

Light ions

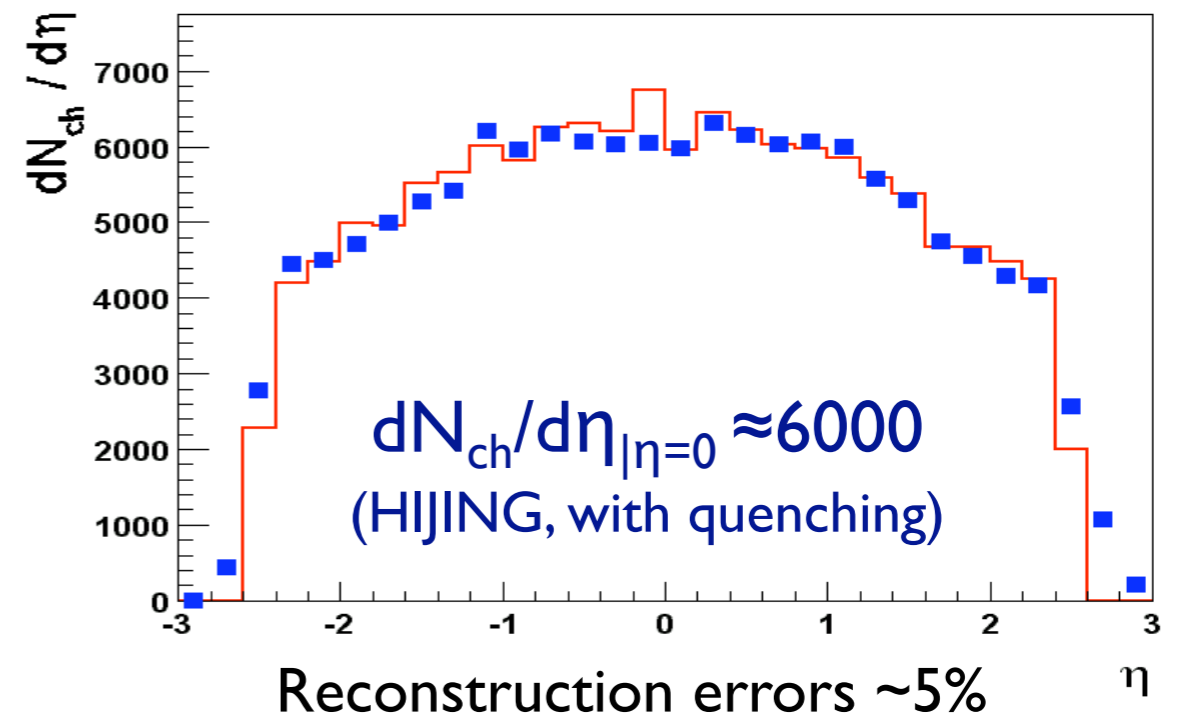
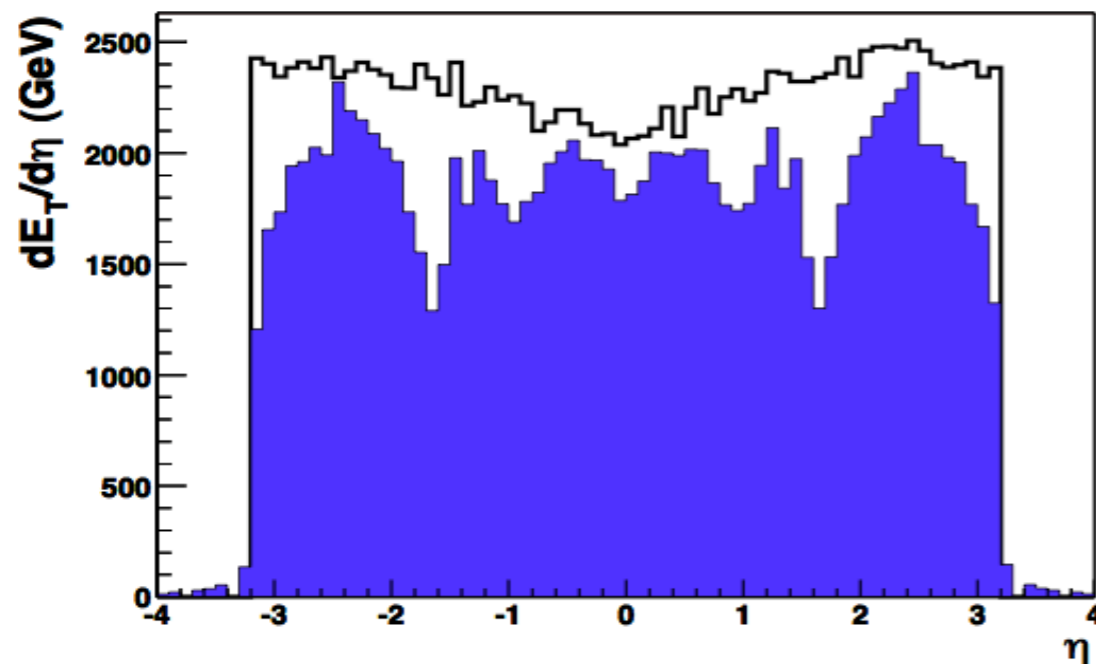
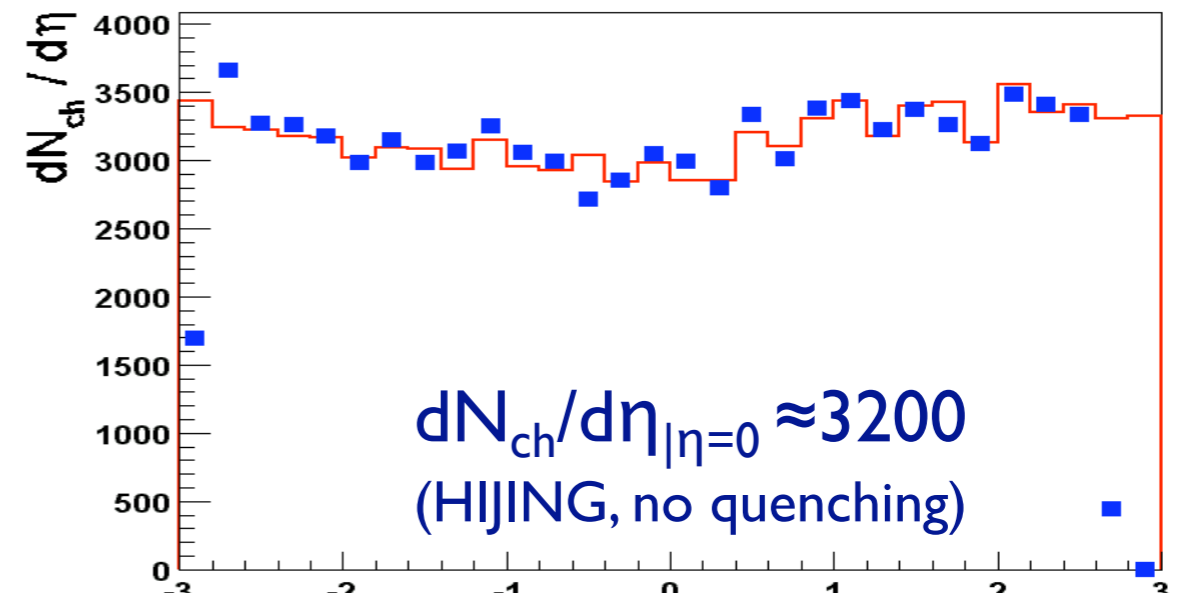
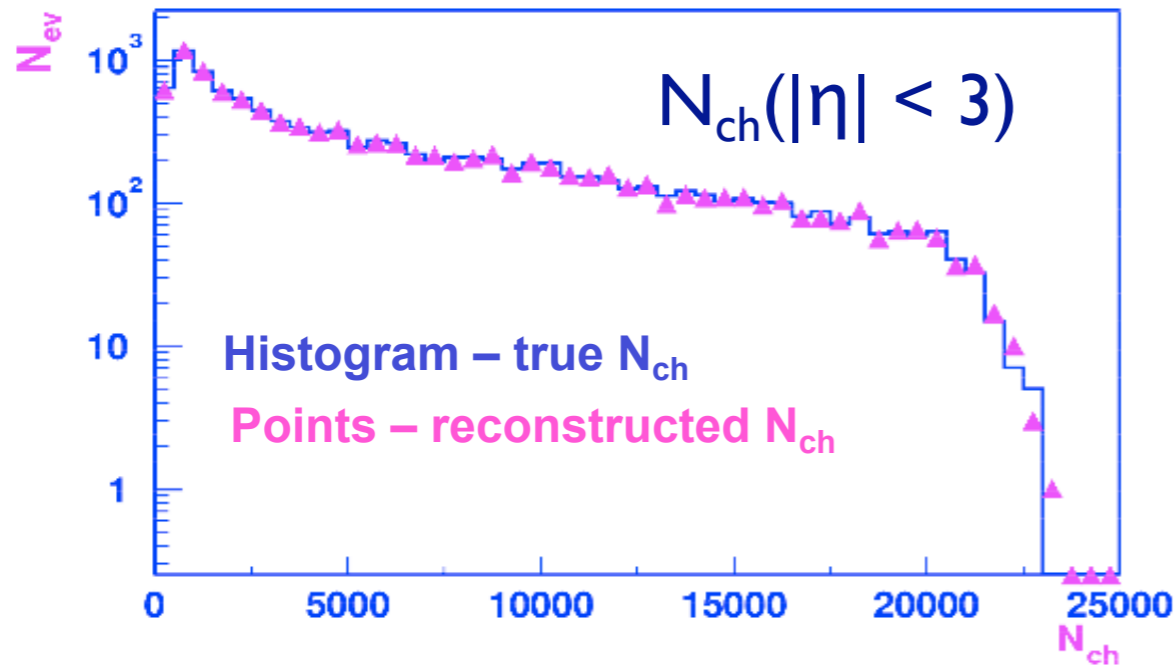
A first study of the detector response using full detector simulations was performed and these studies use the standard ATLAS software.



Global Event Characterization

Day One Measurements: N_{ch} , $dN_{ch}/d\eta$, E_T , $dE_T/d\eta$, b

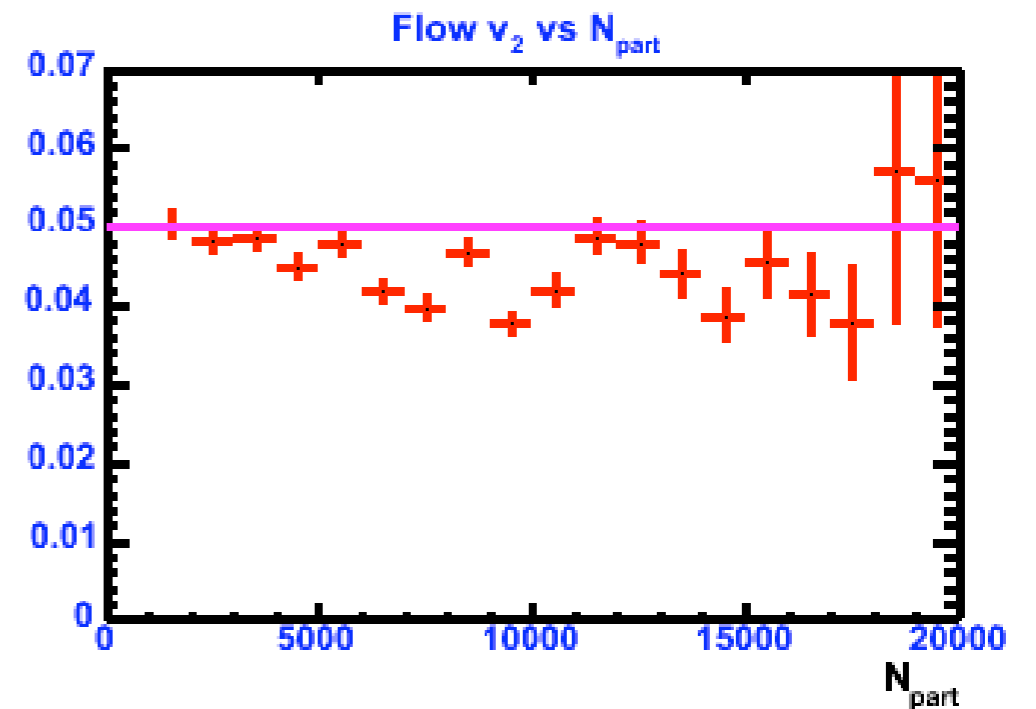
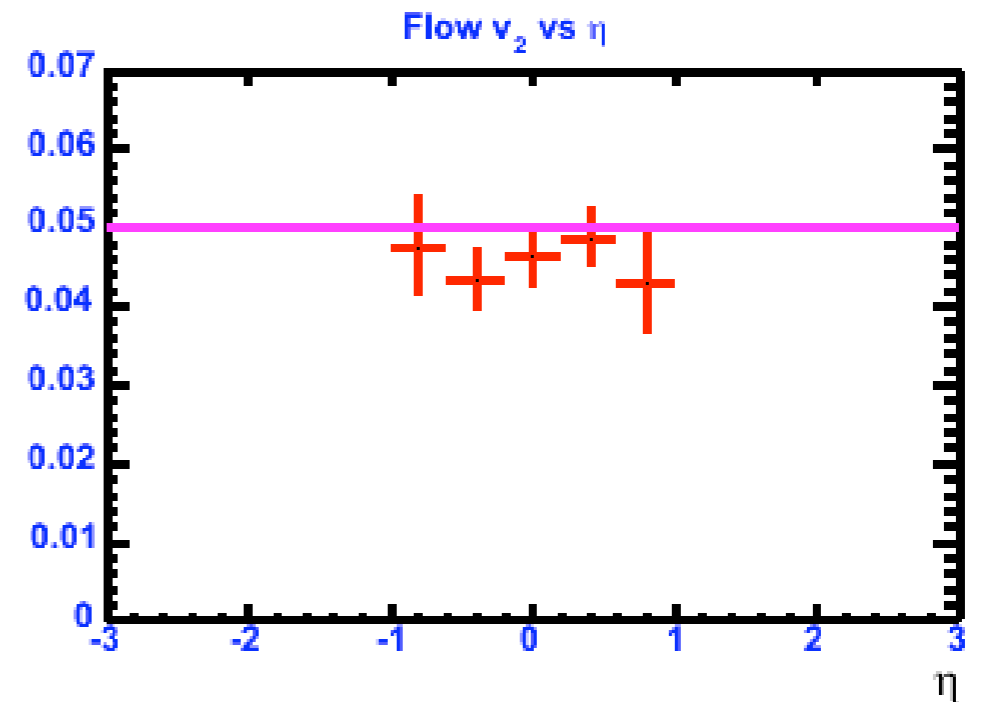
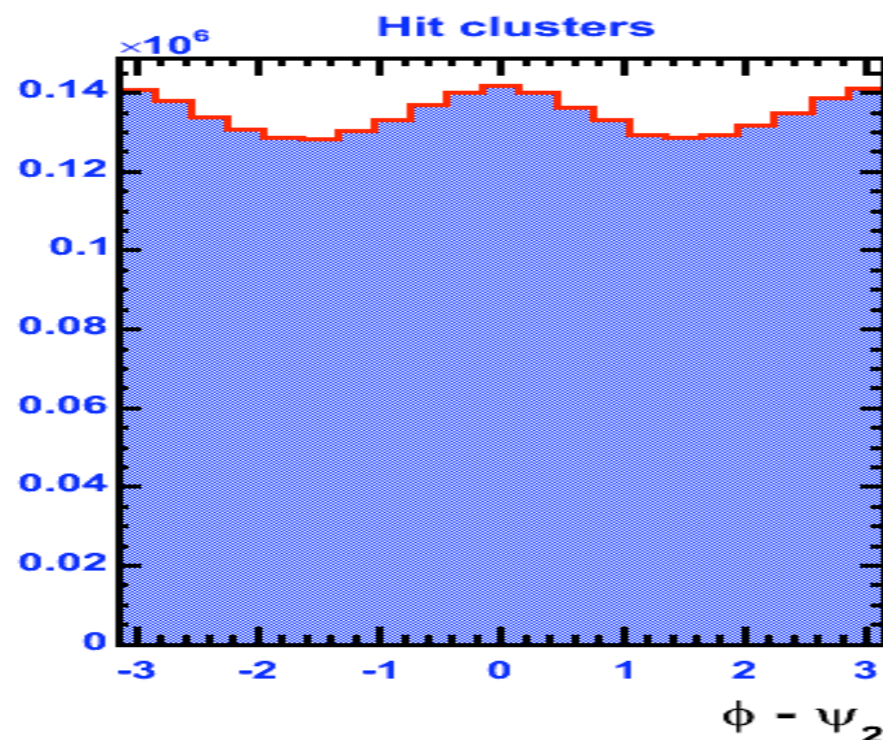
Single Pb+Pb event, $b = 0-1\text{fm}$



Elliptic Flow

v_2 measurable using Pixel (barrel) and Forward Calorimeter
(reaction plane reconstruction)

Generation of HIJING events with flow with
 $v_2 = 0.05$; $\text{const}(N_{\text{ch}}, \eta, y, p_T)$ by modification
of azimuthal angle ϕ



Reconstruction:

~10% is due to non-flow correl. and will be accounted for by MC correction

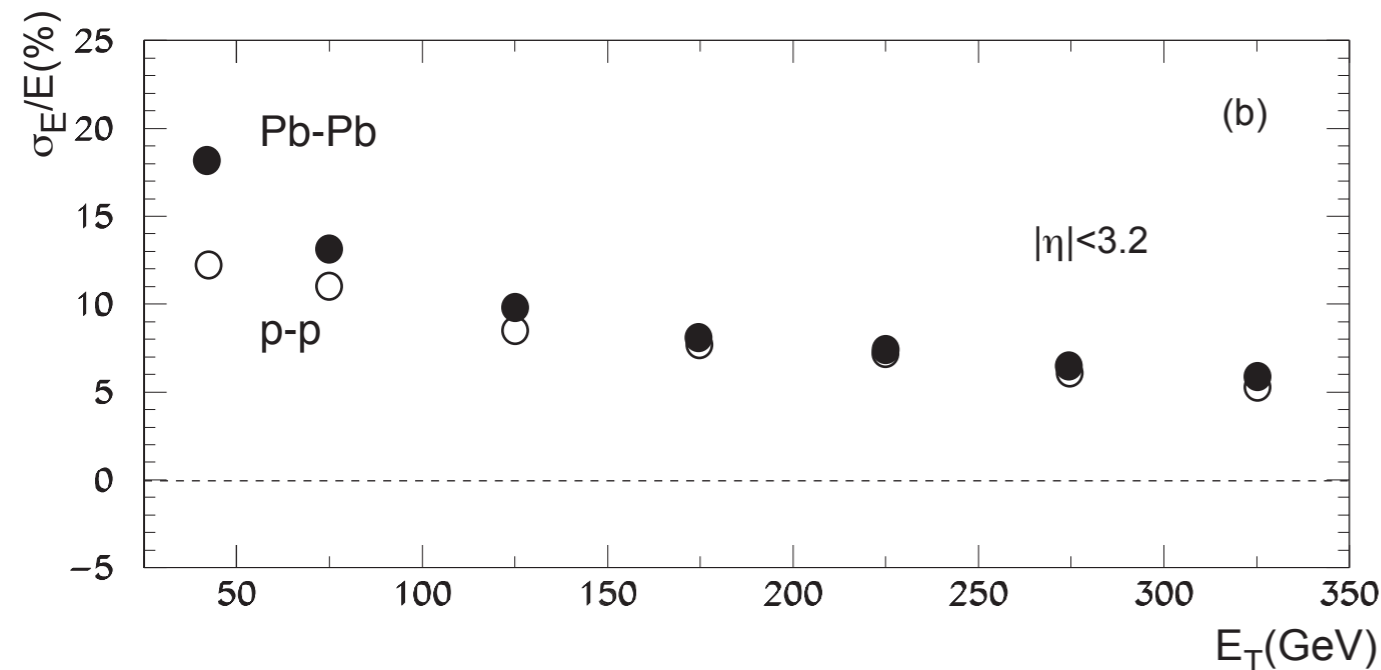
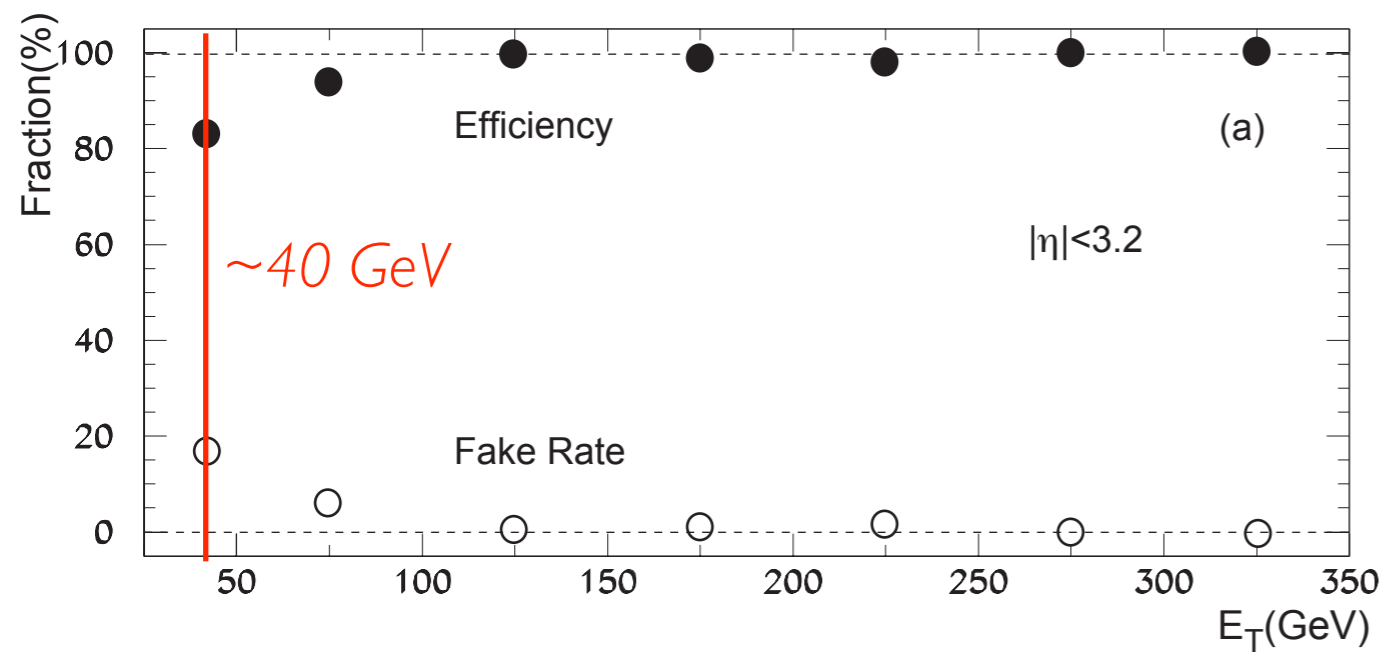
PANIC 2005, Heavy Ions at LHC, October 23, 2005.



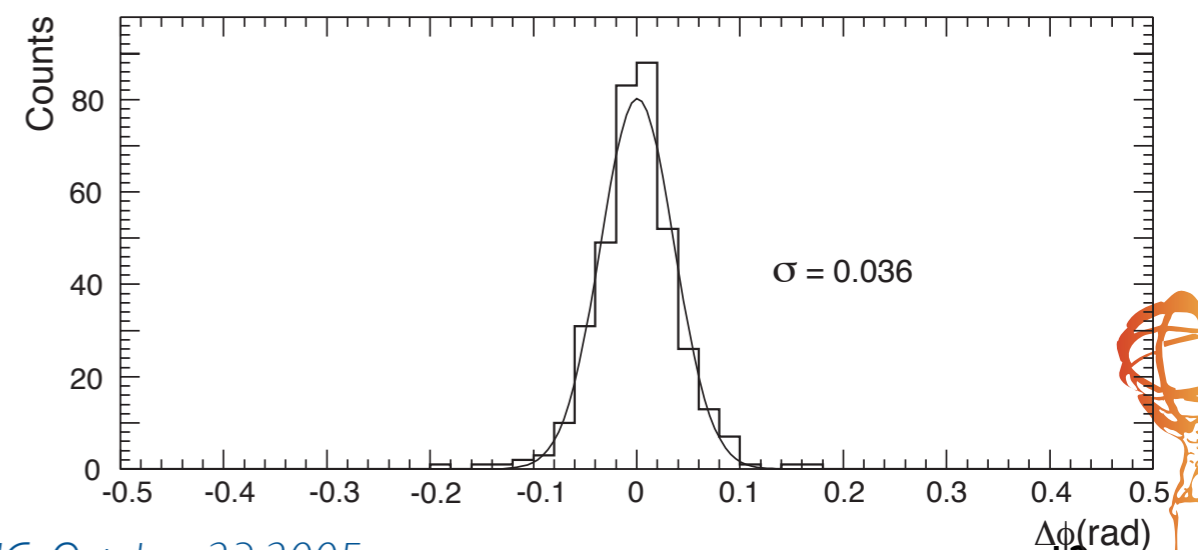
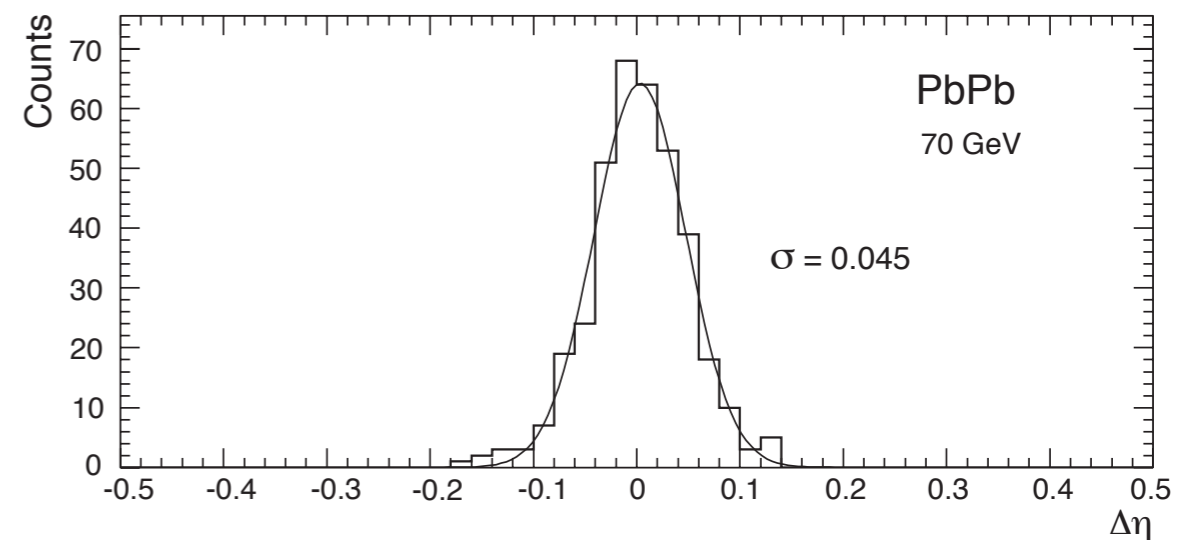
Jet Performance

Window algorithm, with average pedestal subtraction.

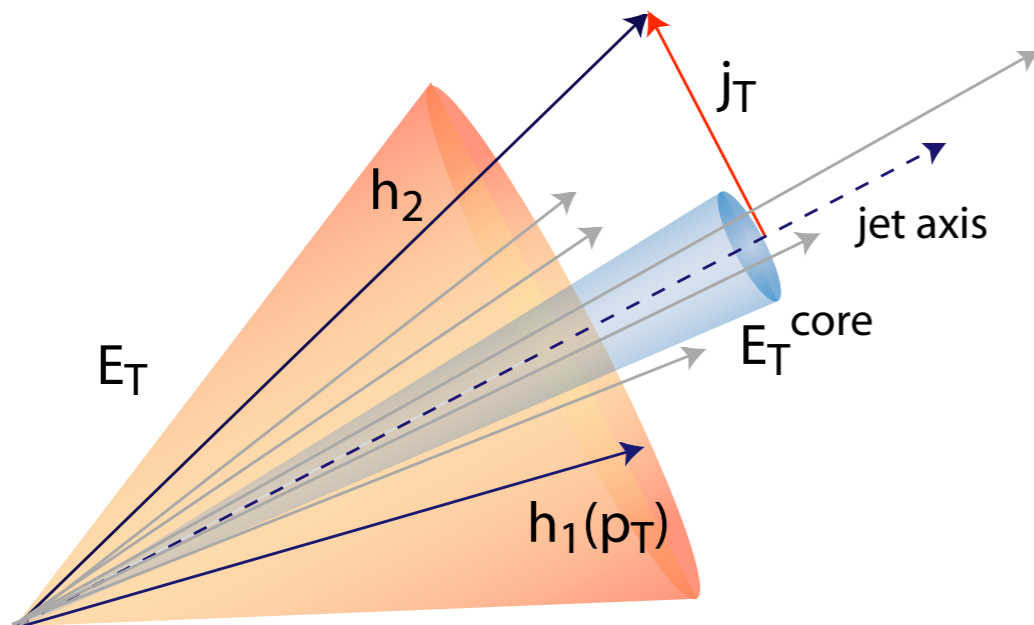
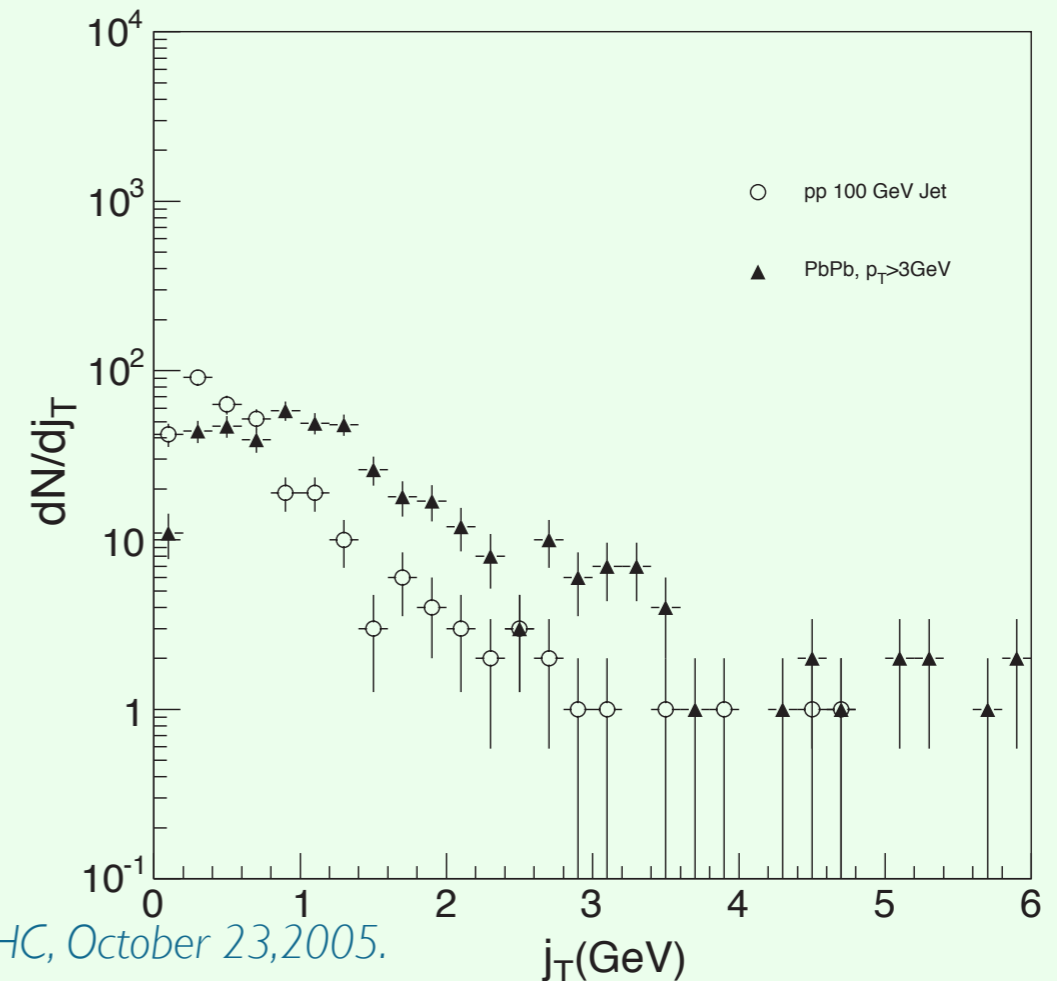
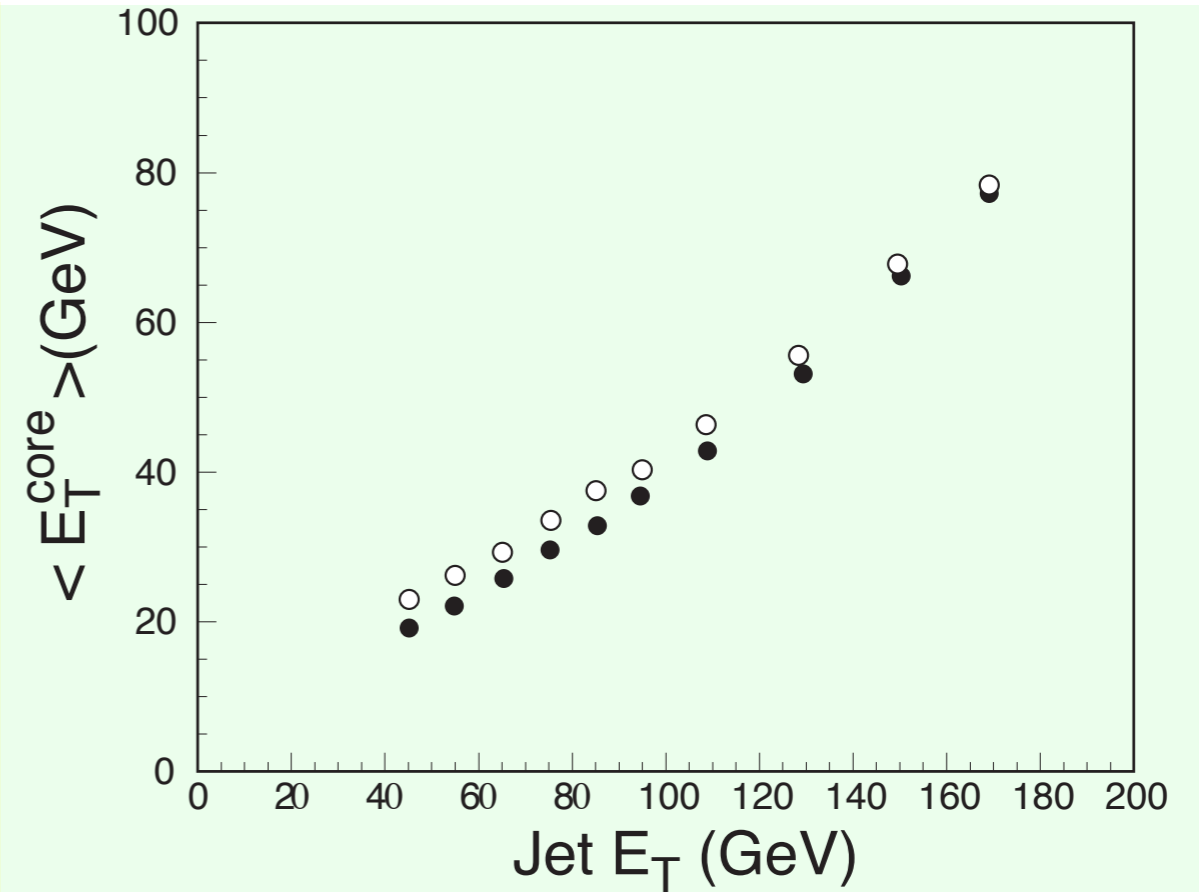
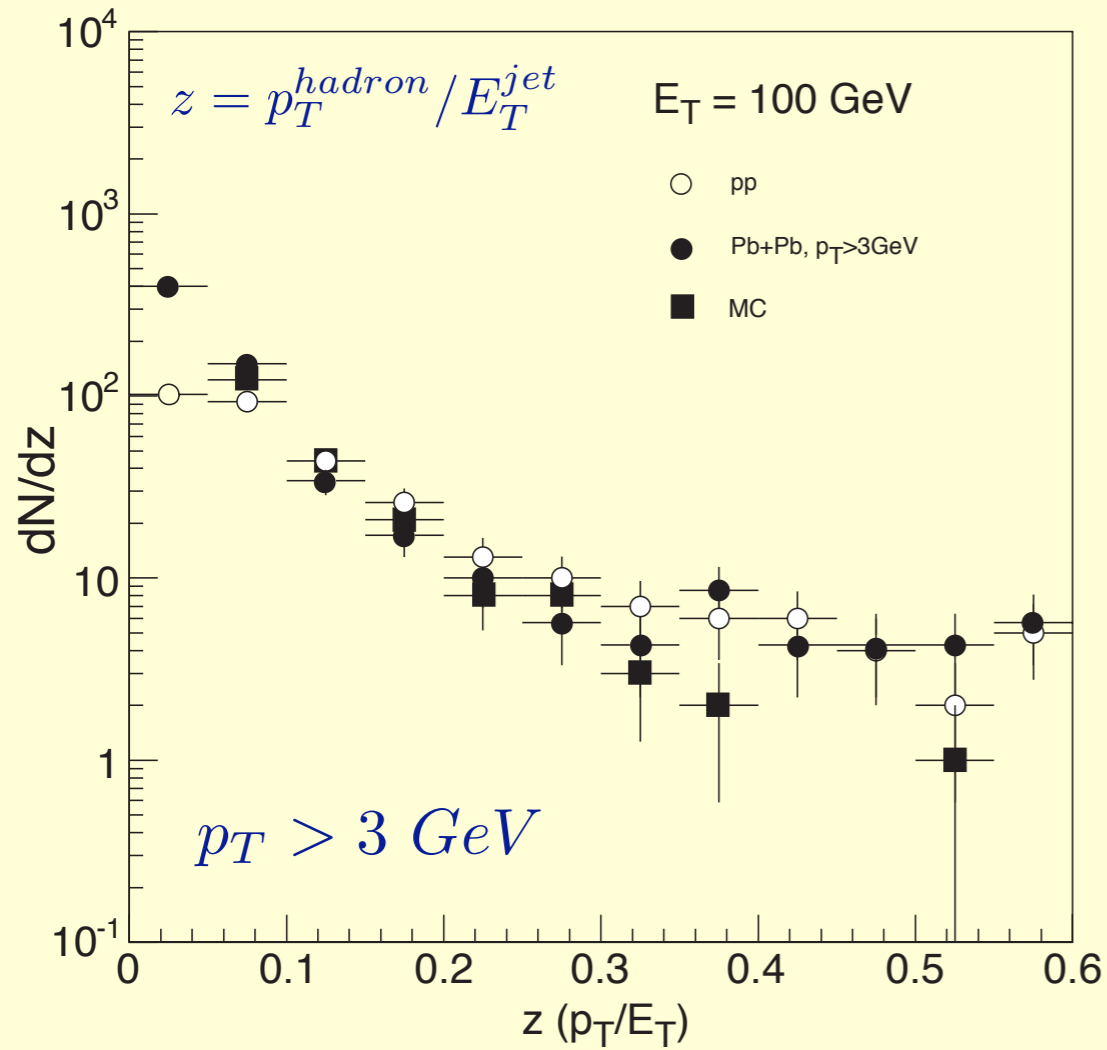
Pedestal subtraction requires more study, especially if background is asymmetric.



jet axis definition is important for measurement of j_T . At the moment it is about a factor of 2 worse than in pp



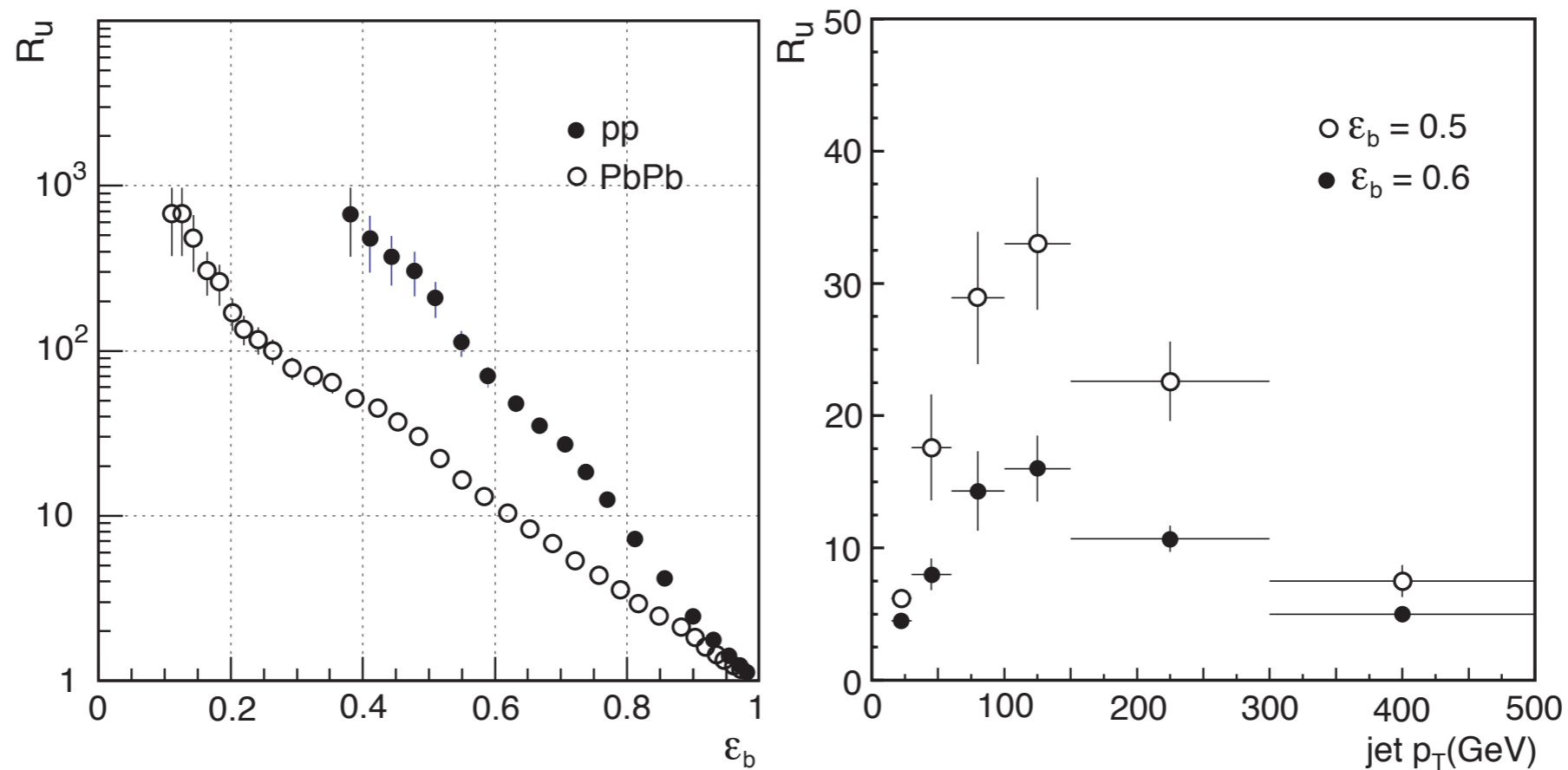
Fragmentation function, j_T and E_T^{core}



b- tagging

Motivation - Heavy quarks may radiate less than light quarks in the hot QCD matter.

A first study of the b -tagging capability in the heavy ion environment was performed by overlapping WH events on HIJING background.

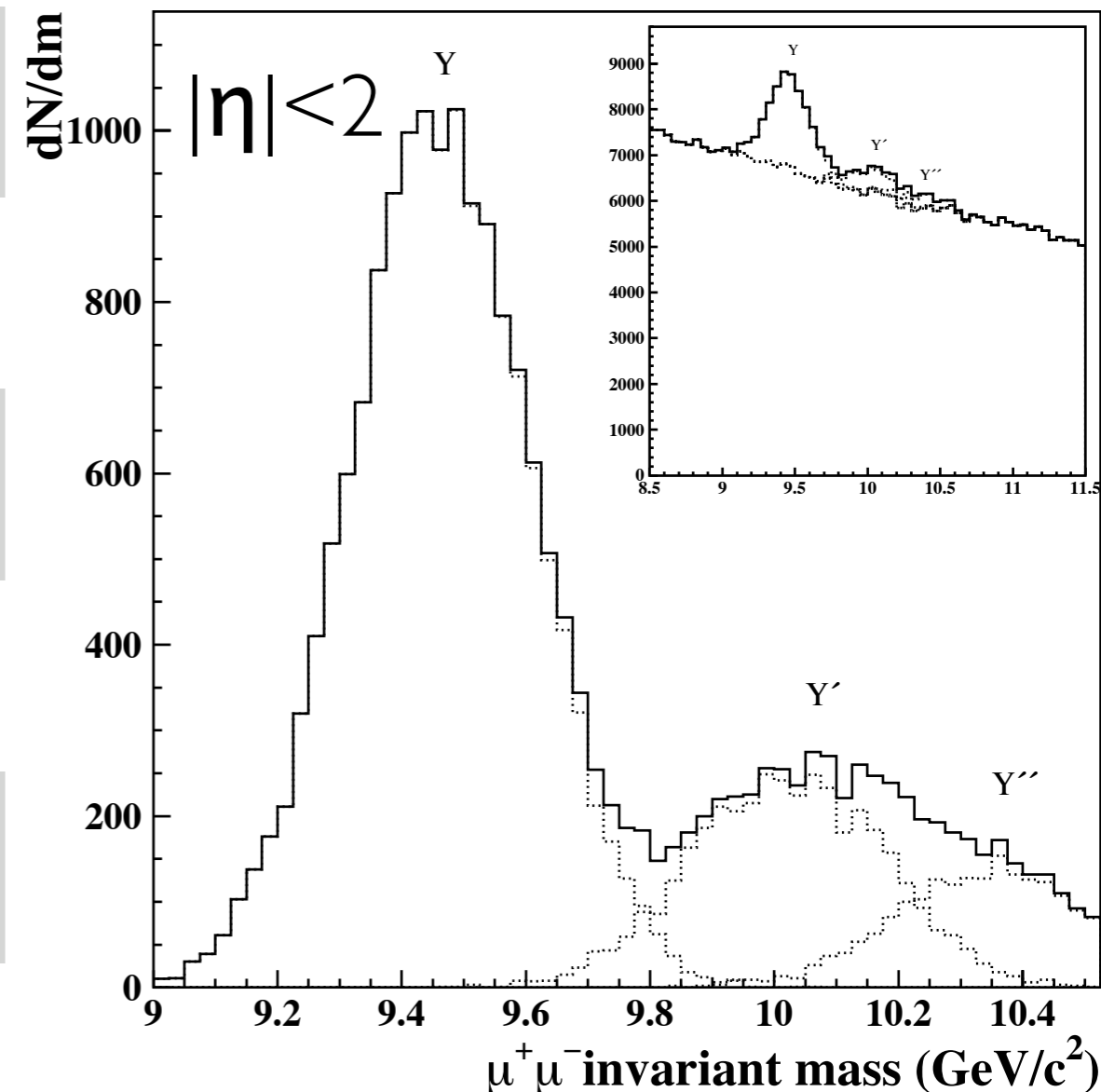


A muon tag will also be used by matching a muon in the spectrometer to the jet axis.



$\Upsilon \rightarrow \mu^+ \mu^-$ Reconstruction

	$p_T(\mu) > 3 \text{ GeV}$		
	$ \eta < 1$	$ \eta < 2$	$ \eta < 2.5$
Acceptance and Efficiency	2.6% 4.7%	8.1% 12.5%	12.0% 17.5%
Resolution	123 MeV	145 MeV	159 MeV
S/B	0.4 0.3	0.3 0.2	0.3 0.2
$S/(S+B)^{1/2}$	31 37	45 46	55 55
	Global Fit	Global+Tag	



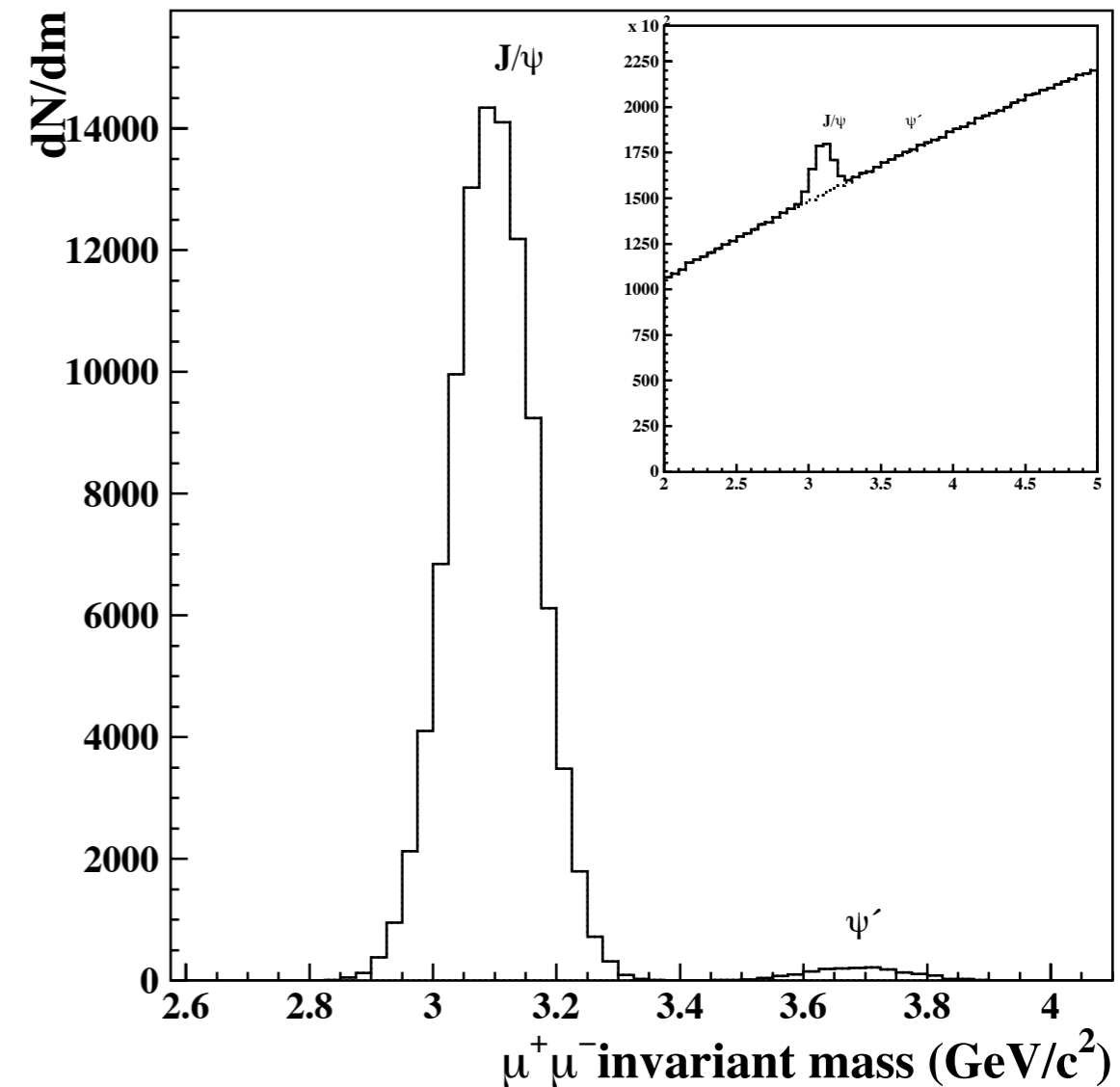
For $|\eta| < 2$ (12.5% acceptance+efficiency) we expect 15,000 Υ per month (10^6 s) at $\mathcal{L}=4 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$

The TRT has not been considered for this study. If N_{ch} allows for its use, the mass resolution will be improved by 25%



$J/\Psi \rightarrow \mu^+ \mu^-$ Reconstruction

	$ \eta < 2.5$ $p_T(\mu) > 3 \text{ GeV}$	$ \eta < 2.5$ $p_T(\mu) > 1.5 \text{ GeV}$
Acceptance and Efficiency	0.039% 0.055%	0.151% 0.530%
Resolution	68 MeV	68 MeV
S/B	0.5 0.4	0.2 0.15
$S/(S+B)^{1/2}$	52 56	72 113
Rate per Month	8000 11000	30000 100000
	Global Fit	Global+Tag



We expect 8,000 to 100,000 $J/\psi \rightarrow \mu^+ \mu^-$ / month (10^6 s) at $\mathcal{L} = 4 \times 10^{26} \text{ cm}^{-2} \text{ s}^{-1}$

If a trigger is possible forward with a muon $p_T > 1.5 \text{ GeV}$, we gain a factor 4 in statistics. A solution might be to reduce the toroidal field for HI runs

Global+tag method increases rate by 3.5 and decreases S/B by 1.5



proton-Nucleus in ATLAS

Study of the modification of the gluon distribution and jet fragmentation function in the nucleus at low x , when gluon saturation occurs (“saturation physics”)

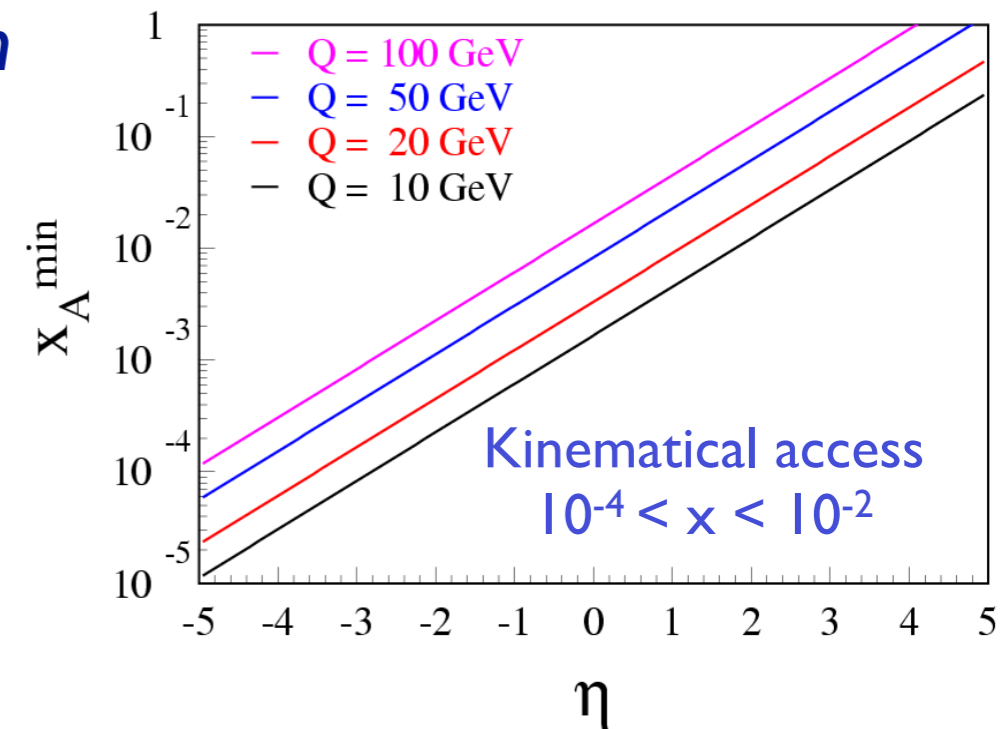
Probe pQCD in nuclear environment

Link between p - p and A - A physics, baseline for HI

p-Pb: $\mathcal{L} \sim 10^{29} - 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$, $\sigma_{\text{TOT}} = 2 \text{ b}$, $\sqrt{s} = 9 \text{ TeV}$, rapidity shift = 0.5

Soft background and occupancy in p -Pb are lower than in p - p with 25 pile-up events

Hermetic calorimeter good for asymmetric collisions; $\Delta Y = 0.5$
 \Rightarrow **ATLAS** is an excellent detector for proton nucleus collisions.



Conclusions

The high granularity of the calorimeter system, external muon spectrometer and tracking capabilities in the high multiplicity environment makes ATLAS ideal for the study of jet physics, quarkonia and minimum bias events in heavy ion collisions.

The study of pp and pA collisions in the same environment will allow for the definition of a solid baseline. Hence the interest in jet physics in pp and pA runs.

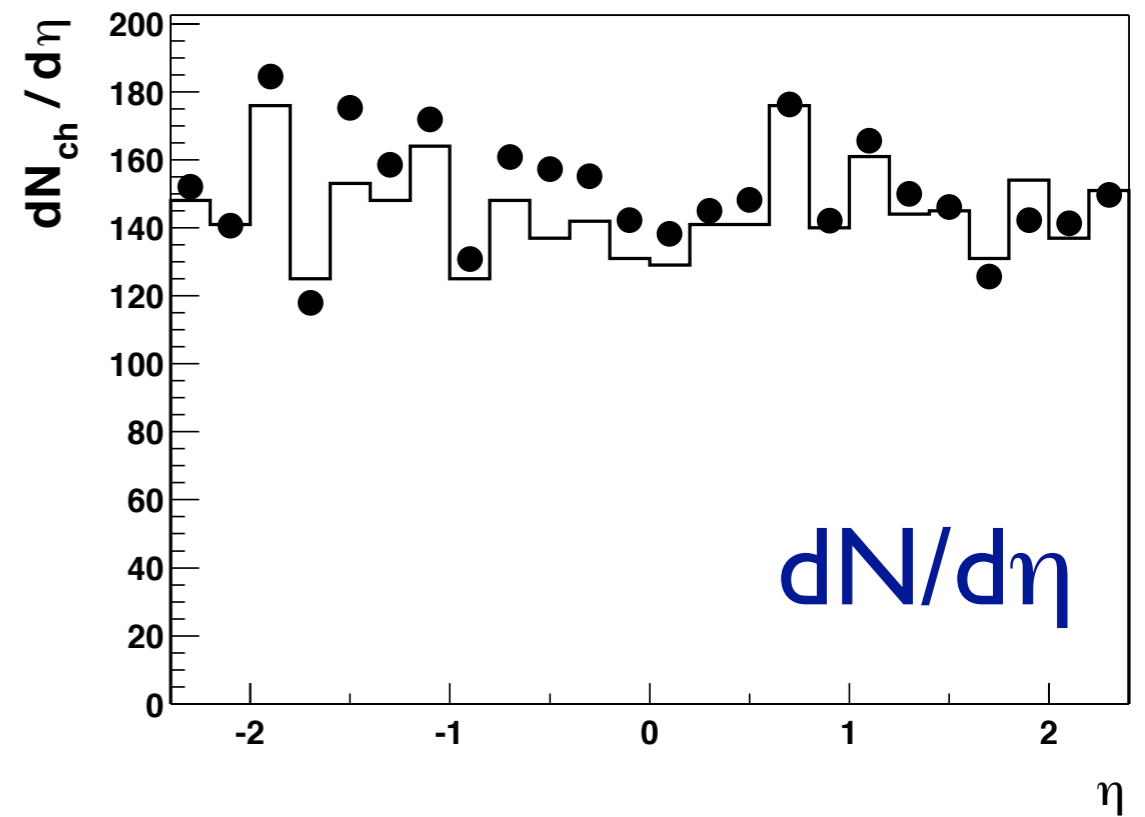
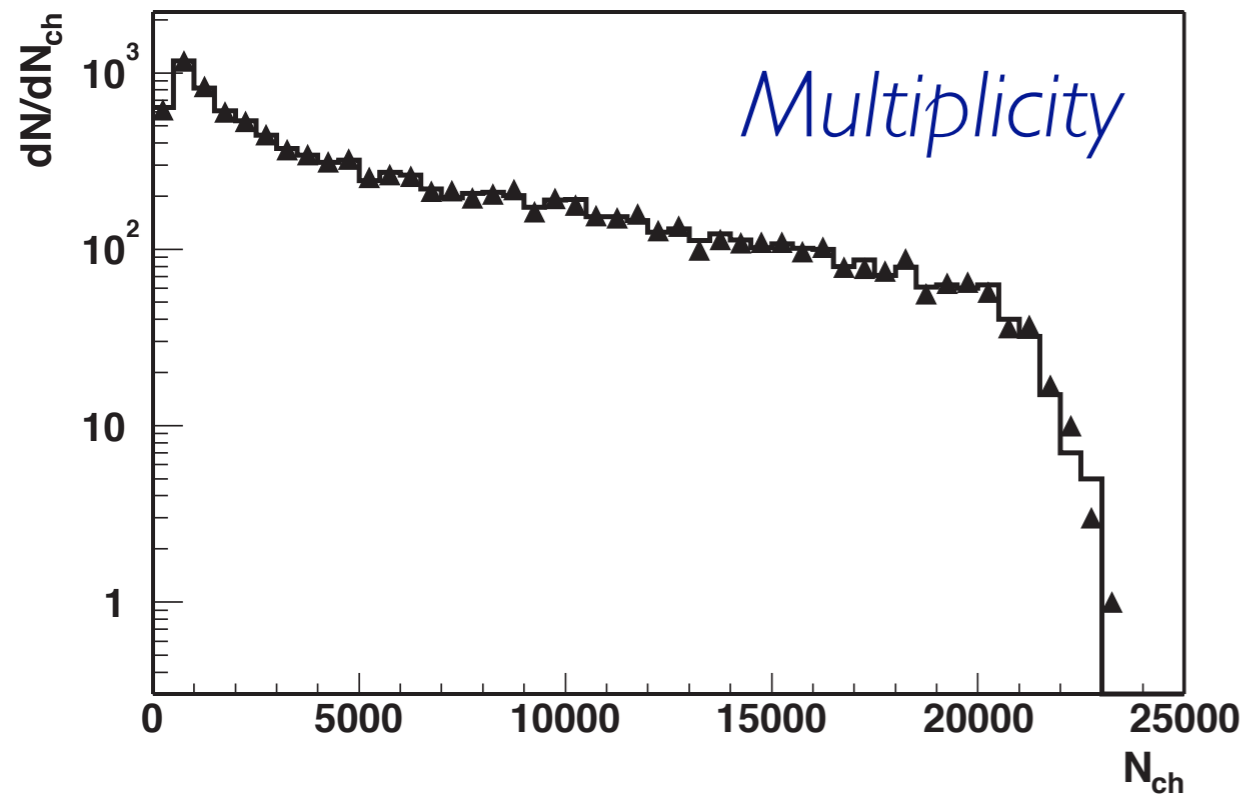
Studies of detector performance is continuing. Algorithms tailored to the high multiplicity environment need to be developed within the ATLAS ATHENA software framework.



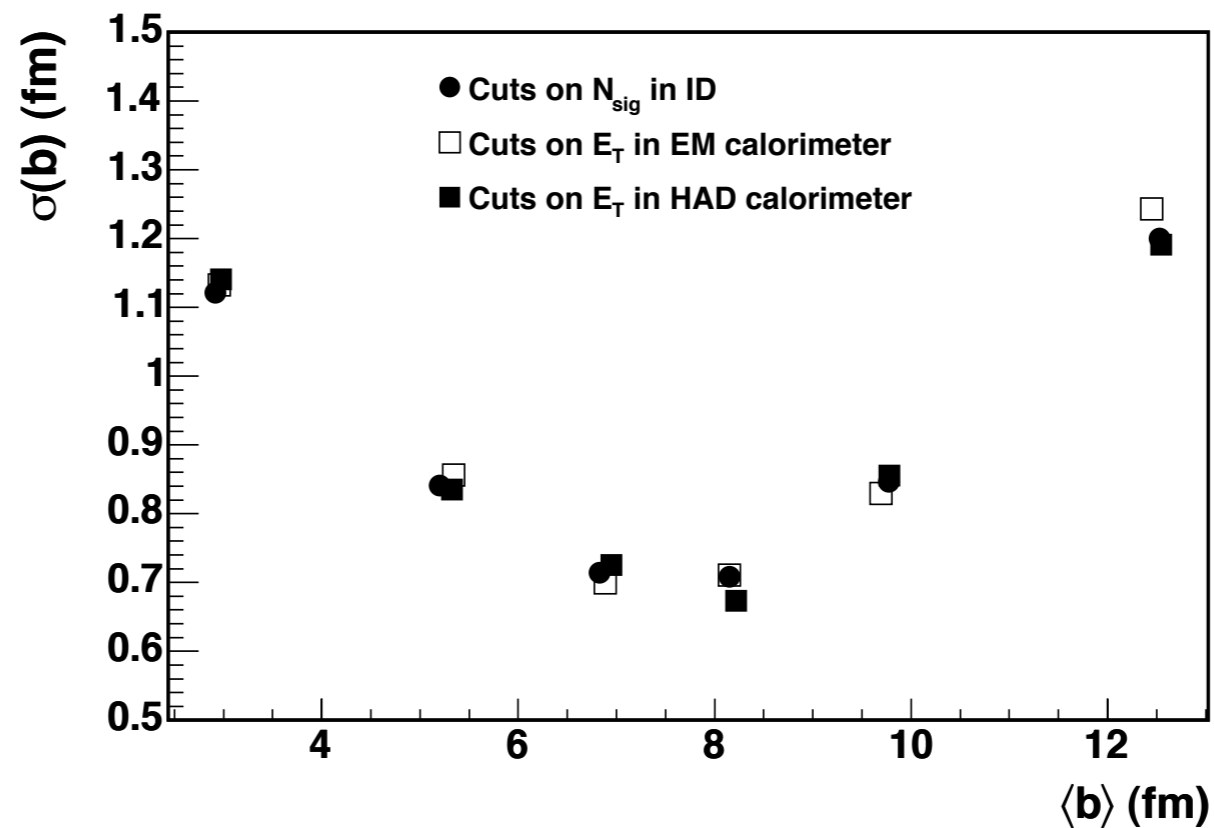
Supplemental Slides



Global Variables



*impact parameter
resolution*



Rates

PbPb collisions will produce large amounts of jets!!!! Each collision will produce **1** (one) $E_T=20$ GeV jet. In each 10^6 s run at nominal luminosity of 4×10^{26} we expect:

p_T threshold	jets
50 GeV	40×10^6
100 GeV	1.0×10^5
200 GeV	2.0×10^4

($|\eta| < 2.5$), A. Accardi, N. Armesto and I.P. Lokhtin, hep-ph/0211314

We also expect ~ 1000 γ +jet events in a 1 GeV bin at $E_T = 60$ GeV
 ~ 500 $Z^0(\mu^+\mu^-)$ +jets total

